

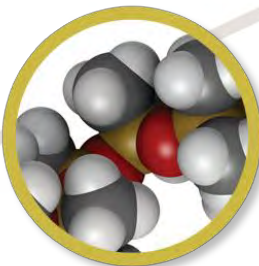


DOW CORNING

Molykote[®] G-900X Series Greases for High Temperature Applications



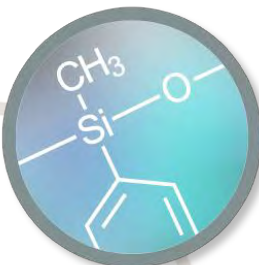
Contents



Polysiloxanes:
Structure and
Properties



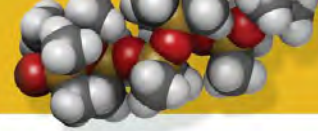
Potential
Applications



Ph/F-Copolymer
Technology and
Properties

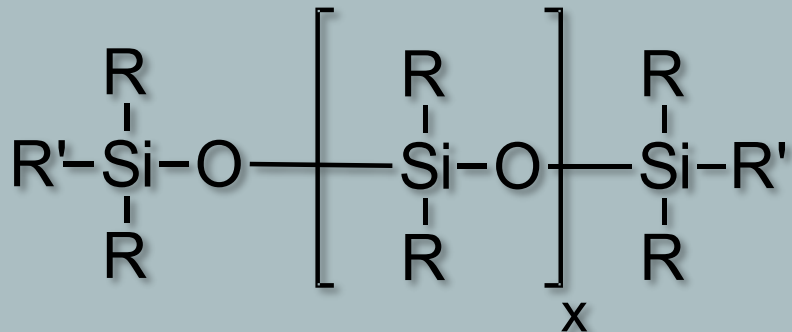


Summary



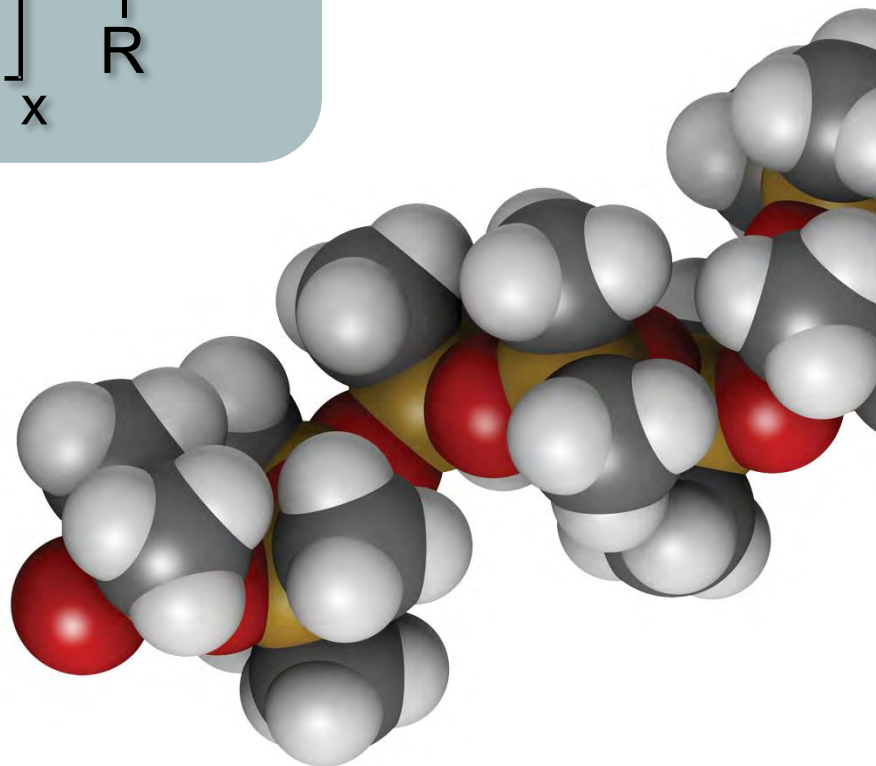
Polysiloxanes: Structure and Properties

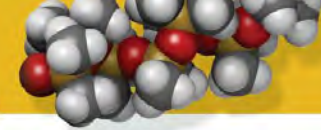
Silicone or Polysiloxanes are chain polymers with an Si-O-Si backbone:



They have some unique properties like:

- High thermal stability
- Chemically inert
- Low surface tension
- High oxidative stability
- Low vapor pressure

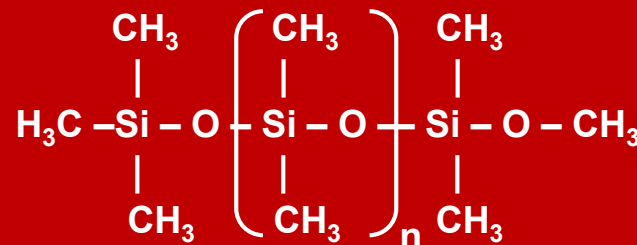




Polysiloxanes: Structure and Properties

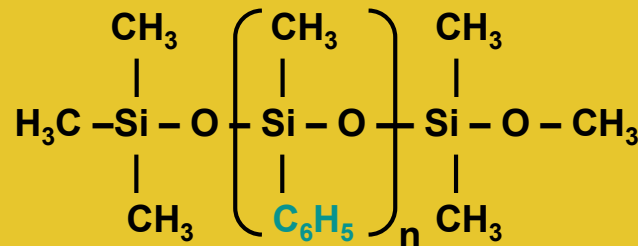
**Dimethyl
Silicone
(PDMS)**

“Standard” silicones



**Phenyl
Methyl
Silicone
(PMPS)**

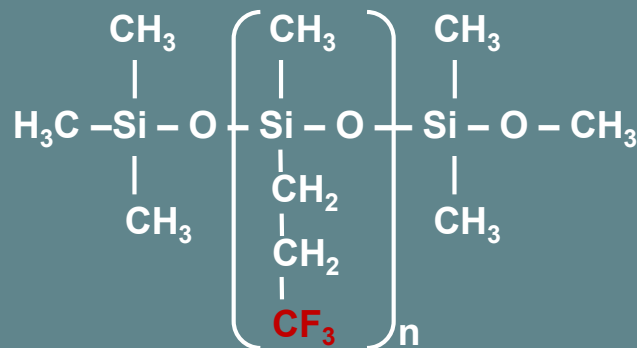
Additional thermal
and oxidation stability

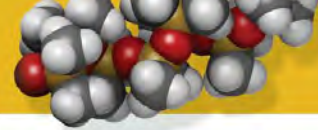


Fluorosilicone
(FS)

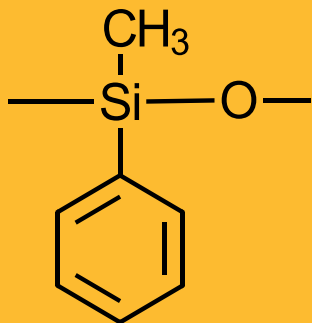
Excellent chemical
resistance

Better load-carrying capacity
and wear resistance



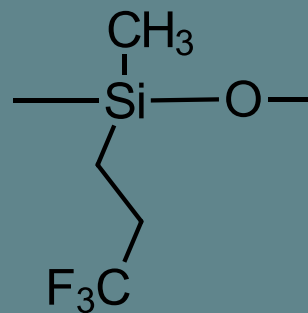


Structure of Phenyl/Fluoro Siloxane Copolymer Lubricants

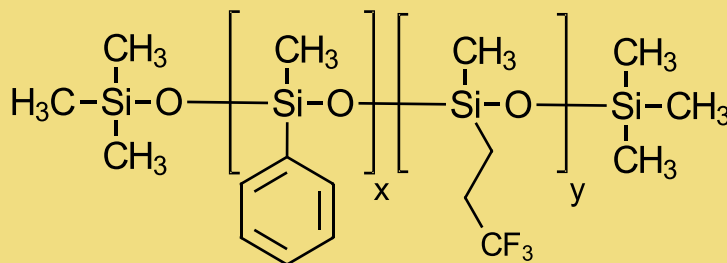


Phenyl

Different Ph/F ratio allows balance between thermal stability and wear resistance



Fluoro

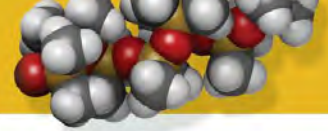


Phenyl/Fluoro Copolymer

Thermal stability

Wear resistance

Additive Acceptance



Polysiloxane fluids have limited miscibility with additives

Fluorosiloxane fluids are immiscible with additives

Phenyl/Fluoro copolymer fluids show **good acceptance with many commercial available additives**

New lubricants using commercial available additives

Copolymer Greases

- Greases can be prepared by using single and complex thickener systems (for example, Li and Li-complex soaps)
- Non-soap thickeners like polyurea or PTFE are also suitable to prepare copolymer greases

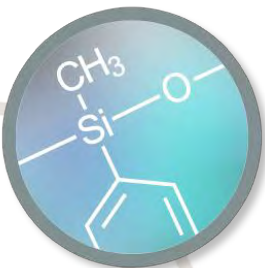
Grease preparation process is similar to current polysiloxane greases



Contents



Polysiloxanes:
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Ph/F Copolymer
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Potential
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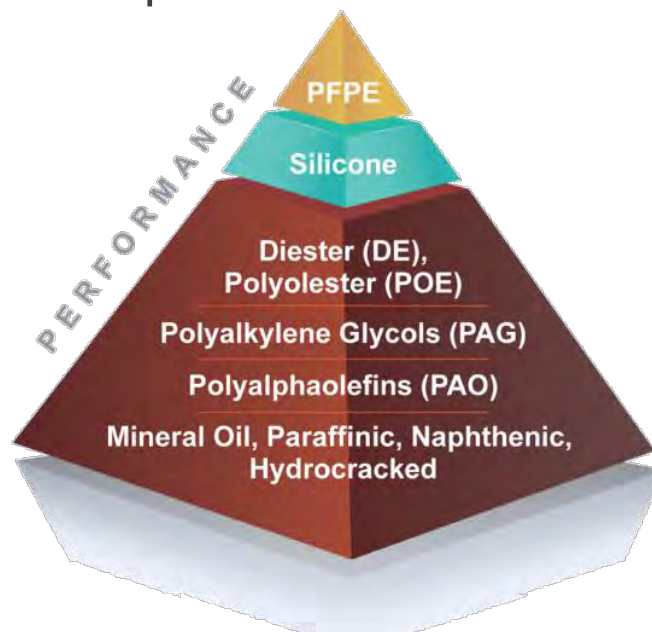


Summary

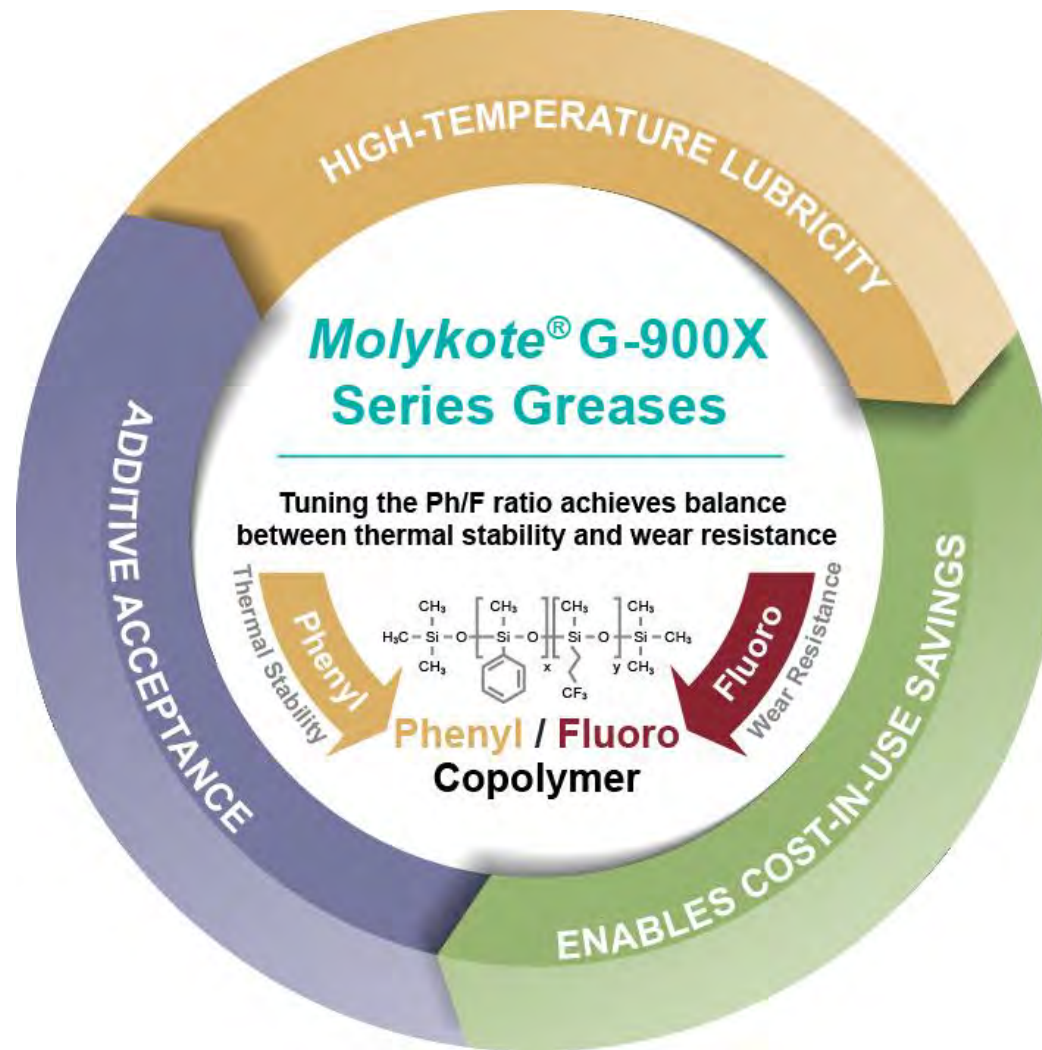
The *Molykote*® G-900X Series Greases Positioning

The *Molykote*® G-900X Series Greases are a new class of silicone lubricants with **significantly improved lubricity** and **high-temperature performance**

A **cost-attractive series of lubricants** in applications that do not require the ultimate high-temperature performance and where ester-based lubricants will be limited in temperature



Molykote® G-900X Series Greases Offering



Molykote® G-900X Series Greases offer high temperature lubricity



Test Method	Norm, Specification	Silicone grease	PFPE grease 1	PFPE grease 2	PFPE grease 3	Ester grease 4	Molykote® G-9001 Grease	Molykote® G-9000 Grease
Base Oil Technology		Ph-Si	PFPE	PFPE	PFPE	Polyol-ester	Si-Copolymer	Si-Copolymer
High-temperature performance: FAG FE9, (6000 rpm & 1.5kN); F ₅₀	DIN 51821 @ 220°C	not tested max service temp is 200°C	15 h	44 h	42 h	Fail	62 h	66 h

Molykote® G-900X Series Greases offer superior performance across a wide temperature range

- Running in bearing applications at **220°C**
- High dropping point (**>280°C**)
- Low bleeding at 200°C (**< 4%**)



**High
Temperature**

- Flow pressure at **-35°C**
< 1000 mbar
- Low temperature torque at
-30°C and -40°C



**Low
Temperature**

Molykote® G-900X Series Greases offer corrosion resistance



Test Method	Norm, Specification	Silicone grease	PFPE grease 1	PFPE grease 2	PFPE grease 3	Ester grease 4	Molykote® G-9001 Grease	Molykote® G-9000 Grease
Base Oil Technology		Ph-Si	PFPE	PFPE	PFPE	Polyol-ester	Si-Copolymer	Si-Copolymer
Corrosion resistance: SKF EMCOR 1 week, dest. water	DIN 51802	1	0-1	0	1-2	0	0	0



Molykote® G-900X Series Greases are a step change in lubricity compared to standard Si-technology

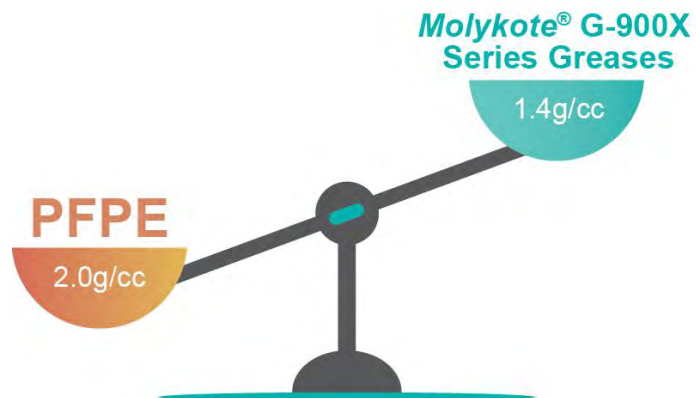


Test Method	Norm, Specification	Silicone grease	Molykote® G-9001 Grease	Molykote® G-9000 Grease
Base Oil Technology		Ph-Si	Si-Copolymer	Si-Copolymer
High-temperature performance: FAG FE9, (6000 rpm & 1.5kN); F ₅₀	DIN 51821 @ 220°C	not tested max service temp is 200°C	62 h	66 h
Four Ball Wear Scar	DIN 51350 Pt4 /NA	2,61 mm	1,18 mm	1,18 mm

Molykote® G-900X Series Greases offer 30% density advantage over PFPE



Test Method	Norm, Specification	Silicone grease	PFPE grease 1	PFPE grease 2	PFPE grease 3	Ester grease 4	Molykote® G-9001 Grease	Molykote® G-9000 Grease
Base Oil Technology		Ph-Si	PFPE	PFPE	PFPE	Polyol-ester	Si-Copolymer	Si-Copolymer
Density @ at 20°C	ISO 2811	1,05 g/cm ³	1,95 g/cm ³	1,95 g/cm ³	1,95 g/cm ³	1,01 g/cm ³	1,42 g/cm ³	1,42 g/cm ³



1 kg of Ph/F Si copolymer grease provides 1.3 x more volume compared to PFPE!



Molykote® G-900X Series Greases

Performance Summary



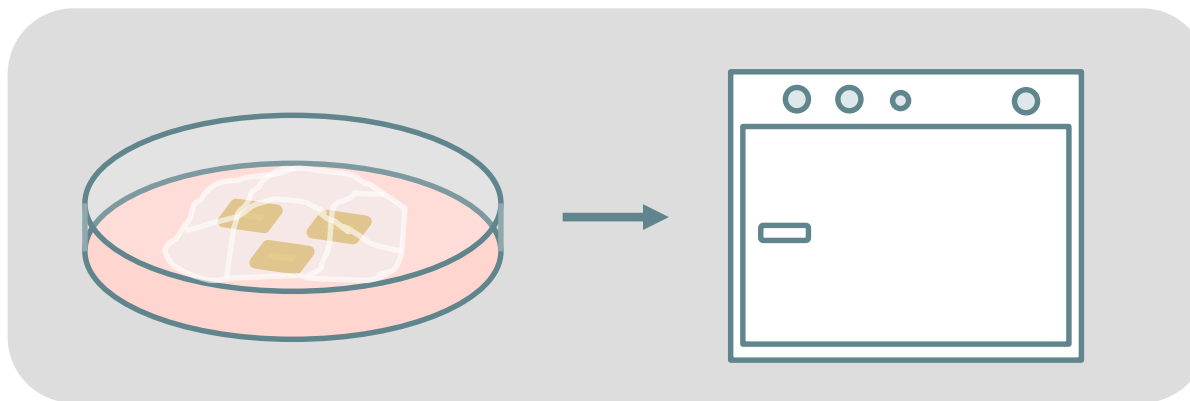
Test Method	Norm, Specification	Silicone grease	PFPE grease 1	PFPE grease 2	PFPE grease 3	Ester grease 4	Molykote® G-9001 Grease (400 cSt)	Molykote® G-9000 Grease (650 cSt)
Base Oil Technology		Ph-Si	PFPE	PFPE	PFPE	Polyol-ester	Ph/F Si Copolymer	Ph/F Si Copolymer
Density @ at 20°C	ISO 2811	1.05 g/cm³	1,95 g/cm³	1,95 g/cm³	1,95 g/cm³	1,01 g/cm³	1,42 g/cm³	1,42 g/cm³
Consistency	DIN 5118 NLGI grade	NLGI 2-3	NLGI 2	NLGI 2	NLGI 2	NLGI 2-3	NLGI 2	NLGI 2
Dropping Point	DIN	220°C	198°C	169°C	161°C	> 295°C	285°C	302°C
Flow Pressure at -40°C	Kesternich test	1150 mbar	1175 mbar	700 mbar	575 mbar	775 mbar	950 mbar	1525 mbar (800 mbar @ -35°C)
Bleed after 24H 200°C	Fed Stan 791-321.2	9.59%	8.74%	12.28%	10.00%	4,50%	3,67%	3,19%
Evaporation after 24H 200°C	Fed Stan 791-321.2	1.75%	0.08%	0.08%	0.14%	2,44%	0,33%	0,36%
High-temperature performance: FAG FE9, (6000 rpm & 1.5kN); F ₅₀	DIN 51821 @ 220°C	not tested max service temp is 200°C	15 h	43 h	42 h	87 h @180°C	62 h	66 h
Four Ball Wear Scar	DIN 51350 Pt4 /NA	2,61 mm	1,45 mm	1,18 mm	0,72 mm	1,03 mm	1,18 mm	1,18 mm
Four Ball Weld Load	DIN 51350 Pt4 /NA	1400 N	7500 N	> 8500 N	> 7500 N	2600 N	2300 N	2300 N
Corrosion resistance: SKF EMCOR 1week, =<1	DIN 51802	1	0-1	0	1-2	0	0	0
Copper Corrosion	ASTM, DC	1b	1a-1b	2b	1b (200° C)	2c	2b (150°C, 3h)	2b (150°C, 3h)



Plastic and Elastomer Compatibility



Elastomers grease-insulated kept in oven for **7 days at 80°C**



	NBR		EPDM		FKM		Si-Rubber	
	Weight change	Shore A change	Weight change	Shore A change	Weight change	Shore A change	Weight change	Shore A change
Molykote® G-9001 Grease	-1,35%	-2	-4,79%	5	-0,41%	2	2,59%	-1
Molykote® G-9000 Grease	-1,27%	-4	-3,20%	3	-0,42%	2	1,89%	0

Note: All elastomers are different and there are a lot of parameters influencing the compatibility. Tests with specific customer samples are recommended before application!



Plastic and Elastomer Compatibility

- Stress cracking with specimen acc. to DIN EN ISO 527-2 Type 1B, **7 days at 80°C**
- Radius of sample holder = 140 mm



Product	POM	PA 6.6	ABS	PC	PEEK
<i>Molykote® G-9000 Grease</i>	No cracking	No cracking	No cracking	No cracking	No cracking

Note: All plastics are different and there are a lot of parameters influencing the compatibility. Tests with specific customer samples are recommended before application!

Paintability

Option 1: The grease is applied crosswise on the substrate and coated directly



Silicone Grease



PFPE Grease



Molykote® G-9000 Grease

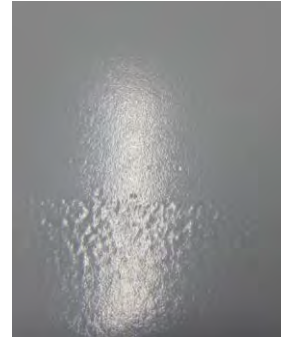
Option 2: The grease will be dry-wiped off after the application and the substrate will be coated



Silicone Grease



PFPE Grease



Molykote® G-9000 Grease

Test method: acc to PV 3.10.7

Paintability



	PDMS-Silicone/LiX Grease	PFPE/PTFE Grease	Molykote® G-9000 Grease
Option 1	Surface defects in the area where grease was applied; adjacent area without the defects	Surface defects in the area where grease was applied; adjacent area without the defects	No surface defects; can be coated
Option 2	Surface defects in the area where grease was wiped off; adjacent area without the defects	Surface defects in the area where grease was wiped off; adjacent area without the defects	Structure difference in the area where grease was wiped off; adjacent area without the defects

Electrical properties



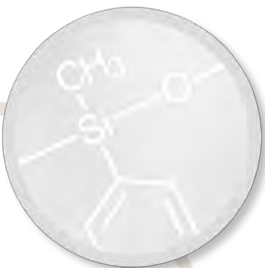
	Dielectric Strength (V/mil)	Volume Resistivity (ohm*cm)
Test method	CTM0114*	CTM0272*
<i>Molykote</i> ® G-9000 Grease	549,2	1.3717 E+12
<i>Molykote</i> ® G-9001 Grease	549,2	9.5917 E+11

* CTM – Corporate Test Methods, copies of CTMs are available on request

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Polysiloxanes:
Structure and
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Ph/F-Copolymer
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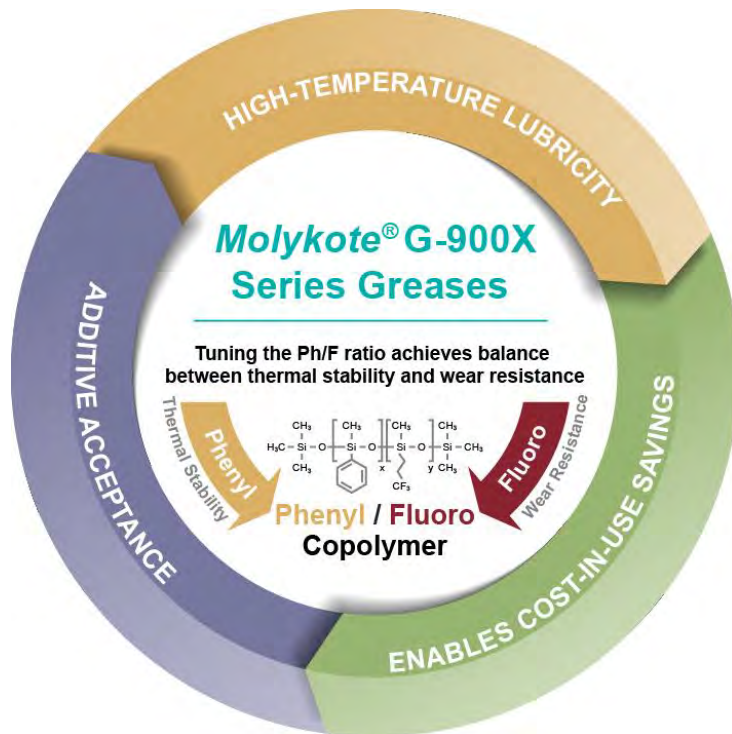
Potential
Applications



Summary



Molykote® G-900X Series Greases are a competitive alternative to PFPE for high-temperature lubrication

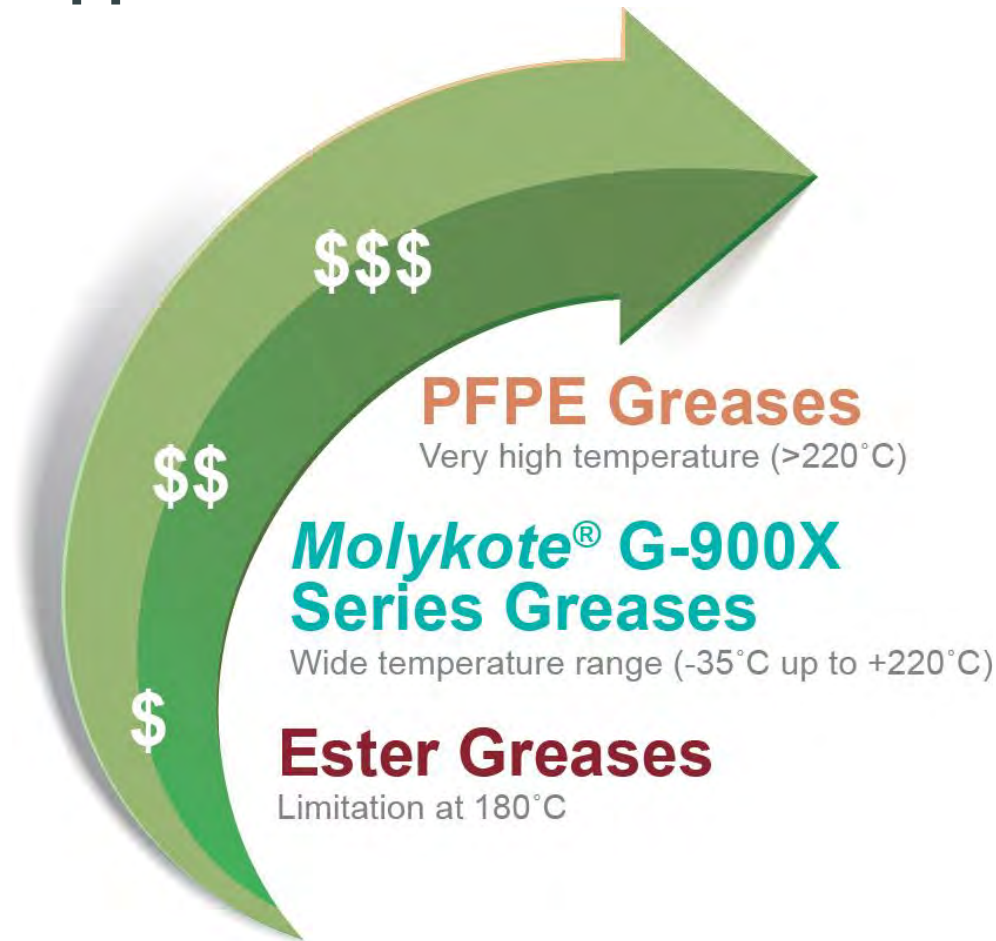


Key Features & Benefits

- Heat stability up to 220°C
- Wide service temperature range (-35°C to 220°C)
- Improved wear resistance
- Good additive acceptance
- Good plastic compatibility
- Easy cleaning
- 30% density advantage over PFPE
 - ⇒ *Cost-in-use advantage*
 - ⇒ *Light weight potential*



Molykote® G-900X Series Greases offer a cost-attractive lubrication solution for high temperature applications



Potential Applications



Auto - under the hood



Tire Molding



Bearing



Textile



Pulp & Paper



Injection Molding



Heat Treatment Furnace



Industrial Equipment



Chemical



Food Processing



Appliances



Metal Processing



Oil & Gas

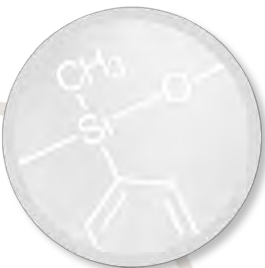


Wood Processing

Contents



Polysiloxanes:
Structure and
Properties



Ph/F-Copolymer
Technology and
Properties



Potential
Applications



Summary

Summary

- Phenyl-/fluoro copolymer siloxane fluids are a **totally new class of lubricating polysiloxane fluids** that opens new opportunities and possibilities
- Their flexible structure allows to design fluids with **high thermal stability** and **improved wear resistance** properties
- Ph/F copolymer fluids have an improved **additive acceptance** which allows to create lubricants for a broad range of applications
- Copolymer greases can be formulated with **different kinds of thickener systems**
- A **cost-attractive series of lubricants** in applications that do not require the ultimate high-temperature performance and where ester-based lubricants will be limited in temperature





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— Thank You

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